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Food Intake and Energy Expenditure of Sailors at a Large Naval Base

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Abstract

Estimates were made of the availability, wastage and intake of food, and of the energy
expenditure of a cohort of eleven sailors over a seven day period at HMAS Albatross, a large
Naval base. In addition, an attempt was made to estimate energy expenditure for an
additional period of approximately nine days. Five members of the cohort were classified as
the 'active group' and the remaining six were 'inactive'. Two methods were used to estimate
energy expenditure - the doubly-labelled water technique and an 'intake/balance' study. The
results below are expressed as kilojoules (kJ) per person per day.

Food availability averaged 20 000 kJ, based on the number of sailors who actually ate
at the mess. Based on victualling strength, food availability was about 10 000 kJ. Wastage
of food amounted to 24% of food availability.

Mean food intake was 13 400 kJ with a standard deviation (SD) of ± 3 925 kJ. Food
intake varied from 9 190 kJ (sedentary female) to 20 030 kJ (male triathlete). Energy
expenditure by doubly-labelled water averaged 13 850 ± 2 510 kJ; the result by the
intake/balance method was 13 200 ± 4 265 kJ.

It is concluded that food availability is more than adequate to meet requirements at
current attendance rates. Food wastage during the period of this study was high. Suggestions
are given on reducing fat and salt intake, and improving the retention of heat-labile vitamins
in cooked foods. Finally, it is concluded that seven days is an appropriate period to study the
energy expenditure of active and inactive subjects using the doubly-labelled water technique.

Approved for public release

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1. Introduction

The Australian Defence Force (ADF) does not currently have a common basis of feeding applicable to all three Services. Army and Air Force feed according to a set of nutritionally-based ration scales known as the Australian Defence Force Ration Scales (DOD. 1988). Navy, on the other hand feeds according to a monetary allowance, the 'Daily Victualling Allowance' (DVA).

In 1987 concern was expressed about the nutritional consequences of feeding according to a financial entitlement, as opposed to the nutritional basis used by Army and Air Force. Consequently, the Director General of Supply - Navy (DGSUP-N) agreed to sponsor a task whose aim is to determine how effective is Naval victualling and, if necessary, to devise a nutritional basis to complement the DVA. Groups being studied are recruits, sailors at a large shore establishment, sailors on a patrol boat, sailors on a large surface vessel and submariners. Interim reports have been sent to the sponsor on studies of recruits (Forbes-Ewan, 1988) and submariners (Forbes-Ewan and Morrissey, 1989).

This report describes a study of the food intake and energy expenditure (EE) of sailors at HMAS Albatross, a large Naval shore base and the Naval Air Station. An interim report giving a summary of the information in this report has already been sent to DGSUP-N (Forbes-Ewan, 1989).

The aims of this study were:

(i) To determine the mean food requirement (as kilojoules (kJ) per person per day) of sailors living at HMAS Albatross;

(ii) To identify any inadequacies or excesses in their diets;

(iii)   To determine the efficiency of the Main Galley in meeting sailors' requirements (i.e. estimate food availability and food wastage);

(iv)   To gain objective information on the acceptability of meals served in the Main Galley.

In choosing a representative cohort as the study group, it was believed that a wide cross-section of occupations, ranging from relatively sedentary to very active, should be represented.

Although the occupations at HMAS Albatross are varied, with respect to physical work output the range is quite narrow. A 'reconnaissance' visit revealed that the physical workloads vary only from low to moderate, and many jobs are virtually sedentary. However, all the Services consist largely of young men, many of whom are physically active outside working hours. Sport is encouraged. Because many sports people expend large amounts of energy playing and training for sport, it was considered important that at least some active sportsmen or women be included in the study group. Volunteers were sought and eleven sailors (10 male and 1 female) agreed to take part in the study. Six subjects were classified as sedentary. Two were very active, engaging in farm work and/or moderate levels of 'fitness oriented' physical activity. Three subjects were extremely active, devoting two hours or more each day to moderate or very vigorous physical exercise. Two of these subjects were triathletes in training for a competition.

EE was estimated using the doubly-labelled water technique. This involves the estimation of carbon dioxide production by determining the elimination rates from the body of the stable isotopes deuterium (D) and oxygen-18 (^{18}O). The method was developed by Lifson and McLintock (1966) for use in small animals. Its first use with human subjects was described by Schoeller and van Santen (1982).

Although the method has been validated under laboratory conditions (Schoeller et al, 1986; Klein et al, 1984), it has not always provided results that agree with those obtained by other methods under field conditions (Westerterp et al, 1986). The protocol of the technique is still being refined and it has been suggested that further studies are needed before the correct assumptions can be said to have been determined (Schoeller, 1988). Therefore, in our studies for Army and Navy we use at least one standard technique to estimate EE, as well as the doubly-labelled water method. In this study we conducted a food intake/energy balance study as a second estimate of energy expenditure. This involved determining changes in body energy reserves and recording food intake.

The seven day food intake study involved estimating food intake from the mess and from all sources outside the mess. An attempt was also made to estimate total food made available to sailors at the General Mess, as well as food wasted. Food wastage was estimated as both kitchen wastage (including preparation and servery wastage) and plate waste.

Food intake and EE were determined separately for two groups: an 'active' group who averaged more than 100 minutes of vigorous physical leisure-time activity per day and an 'inactive' group who averaged less than 8 minutes of vigorous activity per day.

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2. Methods

2.1 Anthropometric Measurements

Age, height, weight and body fat (Durnin & Womersley, 1974) were determined on the evening of day 0. Body fat was also estimated on the evening of day 7. Body Mass Index (BMI) was calculated for each subject according to the formula
$BMI = weight (kg)/height^2 (m)$.

2.2 Food Intake/Plate Waste

Food intake was estimated on an individual basis for each of the eleven subjects. Food obtained from the Main Galley was determined by direct weighing. As well, some food was consumed without weighing. This consisted of ancillary items such as sugar, spreads, instant coffee and condiments. These were placed on a table adjacent to the dining area used exclusively by the study group. Each individual's consumption of these items was estimated according to their disappearance and to the number of meals attended by that individual. For example, if 10 000 kJ of miscellaneous food was eaten and subject number one's meal attendance accounted for 10% of all meals taken, he was assumed to have eaten 1 000 kJ of miscellaneous food.

For each subject, plate waste was separated into individual food components and recorded after every meal eaten in the Main Galley.

Intake from other sources was recorded in a diary; each subject was given instruction in the correct use of the food intake diary and was asked to record actual weight or volume of foods consumed. If this information was not readily obtainable, a description of the serving size was to be given, e.g. 'one large meat pie', 'one small piece of fried fish', and so on. These diaries were checked daily - compliance was believed to be very good.

A nutritional database was used to estimate intake of energy, protein, fat, carbohydrate and a wide range of vitamins and minerals. The database was a modified form of 'NUTTAB', the nutritional database published by the Department of Community Services and Health (1987a). As well as the 'NUTTAB' results, this database has the results of in-house analyses and other results obtained from companies and the scientific literature. Plate waste was estimated as kilojoules (kJ) of edible food remaining on the plate.

In addition, samples were taken of several foods for chemical analysis to check that the results in our database were appropriate, especially with respect to the heat-labile vitamins thiamine and vitamin C.

2.3 Energy Expenditure

EE was estimated by the doubly-labelled water technique and by a food intake/energy balance study.

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2.3.1 Doubly-Labelled Water

The eleven volunteers, who had each signed an informed consent proforma, received isotopically-labelled water (Isotec, Miamisburg, Ohio, USA) after the evening meal on day 0. Each subject received about 5.5 g of 99.9 atom per cent (AP) deuterated water (D_2O) and 115 g of 10 AP $H_2{}^{18}O$. All doses were weighed to ± 0.01 g. Each container was then rinsed with 400 ml of tap water which was also drunk.

The protocol was virtually identical to that previously described (Forbes-Ewan et al, 1988) and had therefore been approved by the Surgeon-General of the ADF following advice from the Ethics Committee of the CSIRO Division of Human Nutrition.

Urine samples were taken immediately pre-dose, 8–10 hours post-dose (on the morning of day 1), seven days after the post-dose sample was obtained (on the morning of day 8) and approximately two weeks post-dose. All subjects were instructed not to eat or drink between administration of the labelled water and provision of the second urine sample. They all reported voiding their bladder at least once during this time; Schoeller et al (1980) reported that the urine sample obtained from the first voiding did not yield an accurate estimate of the initial ^{18}O enrichment.

Urine samples were immediately frozen. They were then sent to CSIRO Division of Water Resources Research for analysis by stable isotope mass spectrometry. Prior to analysis, the samples were azeotropically distilled in kerosene. A VG Micromass 602D mass spectrometer was used to determine D and ^{18}O. D was analysed by reducing 25 mg of distillate in a circulating system with uranium heated to 800°C. For ^{18}O, the Epstein-Mayeda technique, as modified by Taylor (1973) was used.

Total body water (TBW) was calculated as previously (Forbes-Ewan et al, 1988). Briefly, TBW is assumed to be equal to 0.73 times fat free mass (FFM). FFM is calculated from the skinfold estimate of fat mass (see below). The value for TBW used in the calculation of EE was the mean of values obtained on day 0 and day 8.

Carbon dioxide (CO_2) production was calculated according to the equation of Schoeller et al (1986):

$$rCO_2 = (TBW/2.078)(1.01k_o - 1.04 k_H) - 0.0246r_{Gf}$$

where k_H and k_o are the elimination constants for deuterium and ^{18}O respectively, and r_{Gf} is the rate of water loss via fractionating gaseous routes. The value of r_{Gf} is estimated to be 1.05 TBW $(k_o - k_H)$.

EE was calculated from the respiratory quotient of each subject using the constants given by Pike and Brown (1984). Respiratory quotients were estimated from the food quotients determined as part of the food intake study, as recommended by Black et al (1986). Individual and mean results are reported for each of three periods - day 1 to day 8, day 8 to end of study and day 1 to end of study. TBW for each of the second and third periods was based on the skinfold analyses conducted on day 8.

EE was calculated for two subgroups — the inactive sailors (subjects 1–6) and active sailors (subjects 7–11), for the period day 1 to day 8.

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2.3.2 Intake/Balance

An estimate was made of the EE of the study group using the Intake/Balance technique as described by Acheson et al (1980). This involves measuring food intake and changes in body energy reserves to estimate EE according to the equation

$$EE = \text{energy intake} - \text{change in body energy.}$$

Energy intake was measured as part of the food intake study described above. Change in body energy is usually attributable to alterations in body fat levels. In this study, the skinfold calipers method of estimating body fat changes was used (Durnin and Womersley, 1974). This involved taking measurements of skinfold thicknesses at four sites (subscapular, suprailiac, triceps and biceps) by the same experienced operator on day 0 and again on day 8. The energy value of one gram of fat was taken to be 39 kJ.

2.4 Food Availability/Food Wastage

Estimates were made of the total food made available (kJ/person/day) and food wasted from the Main Galley. Stocktakes of all food in the kitchen and dining hall were made at the start and finish of the 7 day study. Kitchen staff were instructed to inform us whenever food entered or left the Main Galley, so it could be taken into account when the final stocktake was made.

Apart from plate waste, food wastage was from two sources - 'kitchen waste' (e.g. meat trimmings, used cooking fat) and 'servery waste', i.e. food which had been placed on the servery but which remained uneaten and was discarded after the meal.

The nutritional database previously described was used to convert food disappearance and food wastage to kJ equivalent.

2.5 Acceptability

An attempt was made to determine the degree of 'customer satisfaction' in the General Mess. Questionnaires were made available to all diners. The questionnaires contained thirty questions covering a wide range of areas. Included were questions on the suitability of meal times, food quantity, cleanliness of the servery and dining room, acceptability of meals and a series of questions on 'other food items' such as bread, milk, fruit and drinks. Questionnaire design was based on advice previously given to MRL Tasmania by an Army psychology unit (1 Psych Unit). A copy of the questionnaire is included as Annex A to this report.

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3. Results

3.1 Anthropometric Measurements

Table 1 shows age, height, initial and final weight, % body fat, fat mass and initial BMI for each subject. Means and standard deviations are also shown. In Table 1 and all the remaining tables, subject number 1 is the female subject, subjects 1–6 constitute the 'inactive' group and subjects 7–11 constitute the 'active' group.

3.2 Food Intake/Plate Waste

Table 2 shows the individual mean daily intakes for energy, protein, fat, carbohydrate (CHO) and alcohol. Results are given for intake from the Main Galley (G), from outside sources (O) and total intake. Also shown is the mean daily intake of each nutrient for male subjects and the recommended dietary intakes (RDI) for energy and protein for moderately active young men (NH & MRC, 1988).

The mean ratio of the contributions of protein, fat, carbohydrate and alcohol to total energy intake was 16:35:47:2.

Mean daily intake for all subjects (male and female combined) from the Galley was 9 450 kJ. Outside the Galley, mean intake was 3 950 kJ. Therefore, intake averaged 13 400 kJ per person per day, of which 71% came from the Galley. Daily food intake varied from 9 190 kJ (sedentary female) to 20 030 kJ (male triathlete in training).

Plate waste averaged 500 kJ per person per day. On a 'per meal' basis, plate waste averaged 230 kJ per person.

Table 3 shows intakes of a range of minerals: sodium, potassium, calcium, phosphorus and iron. Also shown is the mean daily intake of each mineral by all male subjects and the RDI (NH & MRC, 1988).

Table 4 shows the corresponding values for a range of vitamins. Most subjects had intakes of vitamins in excess of RDI according to the results obtained using our nutritional database. However, some foods were placed on the servery for up to two hours before the meal began, and may not have been eaten until one hour into the meal time. Under these conditions, heat-labile vitamins, especially vitamin C and thiamine, are rapidly degraded. Analysis of several foods showed that this happened at HMAS Albatross. As an example, cooked brussels sprouts, which normally would provide about 50 or more mg/100 g of vitamin C, had 1 mg/100 g after 90 minutes on the bain marie.

3.3 Energy Expenditure

3.3.1 Doubly-Labelled Water

Table 5 shows the results of isotopic analysis of urine samples. Values are given as °/oo deviation from the standard - Vienna Standard Mean Ocean Water (SMOW).

Table 6 shows individual values, means and standard deviations for TBW, k_H, k_o, CO_2 production, RQ and EE for the entire group for each of three periods - day 1 to day 8 (period 1), day 8 to end of study (period 2) and day 1 to end of study (period 3).

Mean EE by doubly-labelled water method for the period coinciding with the food intake/energy balance study (Day 1 - Day 8) was 13 850 kJ per day with a standard deviation (SD) of ± 2 510 kJ per day. The corresponding result for the active group was 16 050 ± 1 200 kJ per day; for the inactive group it was 11 830 ± 1 620 kJ per day.

3.3.2 Intake/Balance

Table 7 shows the individual values, means and standard deviations for the results of the estimation of EE by the intake/balance method. Mean EE of the active group was 16 070 ± 3 010 kJ per day; for the inactive group, it was 10 790 ± 3 730 kJ per day.

3.4 Food Availability/Food Wastage

Based on actual attendance figures, average energy made available to each sailor eating at the Main Galley was estimated to be 23 540 kJ per day. However, subsequent correspondence with the Supply Officer at HMAS Albatross indicated that some food had been removed from the Galley without our knowledge. The energy value of this food was estimated to be 3 000 – 4 000 kJ per person per day, based on the difference between our records of the food removed and the records provided by HMAS Albatross. It is therefore likely that food energy available was about 20 000 kJ. Of this 2 830 kJ was discarded from the servery; this constitutes about 14% of the total food made available. In addition, about 1 500 kJ was discarded as kitchen waste; this was predominantly meat trimmings and used cooking fat. Therefore, wastage (apart from plate waste) accounted for about 22% of the food made available. Including plate waste, total wastage was 24% of food availability.

Meal attendance averaged 171 per day (49% of victualling strength). Based on victualling strength rather than actual attendance, food availability was about 10 000 kJ per person per day.

3.5 Acceptability

Of the 400 questionnaires placed in the Main Galley, 23 were completed and returned. This represents a return rate of about 7% based on victualling strength. The average 'customer satisfaction rating' was 58%. The majority rating of overall performance was 'average'. Several members of the mess who did not attend for meals were interviewed. These were health- and weight-conscious females. They stated that they did not attend because it was difficult to obtain food which was low in fat, sugar and salt, and no true vegetarian meals were provided. These complaints coincided with the most common criticisms of the sailors who completed questionnaires:

Too much fatty food;
No grilled meat (all grilled meat is shallow-fat fried);
Vegetables are often covered with fatty sauces;
No true vegetarian meals;
Fruit is often old and bruised.

4. Discussion

Mean height, weight and BMI of male subjects were similar to the values found for young Australian men by Fisher and Read (1982). Mean body fat percentages were just below the middle of the 'acceptable' range for young men (Durnin et al, 1984). Mean BMI was close to the middle of the 'normal' range (NHF, 1983). The female subject had a body fat level and BMI equivalent to a mild degree of overweight.

Subjects were apparently in, or very close to energy balance during this study; mean weight rose by 0.2 kg, most of which is attributable to an increase in body fat levels. However, this is only a small increase and it is within the experimental error involved in estimating body fat levels.

In summary, the cohort consisted of people with physical characteristics very similar to those of civilian Australians in the same age group. With respect to physical activity, there were two discrete groups. Because the 'active' group was more active than would usually be found in a Naval population, and constituted almost 50% of the cohort, the results for mean EE and food intake are likely to be towards the high end of the range expected at a Navy shore mess. Results for the active group would be expected to equal the likely maximum levels of food required by any group of shore-based sailors. Similarly, the results for the inactive group probably set the minimum requirements.

From the food intake results it appears that provision of enough food to allow a daily intake of about 13 500 kJ per person per day is sufficient for large Naval shore establishments, if all members derive all their food intake from the Naval sources. If a subgroup within that establishment is engaged in very hard physical work or training, their intake will   probably be in the range 15 000 – 16 000 kJ. If activity levels are very low, the requirement is likely to be in the range 11 000 – 12 000 kJ.

The 'average' requirement of about 13 500 kJ is close to the RDI of 13 200 for young, moderately active male Australians (NH & MRC, 1988).

For the period coinciding with the food intake study (days 0–8), the doubly-labelled water and intake/balance results for mean EE are similar to the food intake results, providing support for the above conclusions.

Three aspects of these results need to be addressed. Firstly, the study cohort constituted only a very small percentage of the total population at HMAS Albatross. It is possible that they had metabolic rates which were unrepresentative, and that food requirements have not been properly defined. However, this is unlikely. Although metabolic rate varies widely between individuals, its main component, resting metabolic rate, varies only slightly per unit of fat-free mass; the coefficient of variation is about 12.5% (James, 1985). The study group consisted of young men and one woman with no abnormal anthropometric characteristics. The population they represented is also predominantly young, male and must conform to guidelines on acceptable weight for height.

The study cohort did contain several sailors who were extremely active physically, but the remainder were almost completely sedentary. Our understanding is that this variation in activity levels is common throughout the Navy and that there is no reason to believe that the cohort was unrepresentative, or that the results do not apply to the general Naval shore population (with the caveat, previously mentioned, that these results may be towards the high end of the normal range).

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Secondly, the actual amount of food which must be provided to allow an intake of 13 500 kJ will be greater than this figure, because some food is inevitably wasted in institutional feeding. Wastage occurs at three points: during preparation, at the servery and on the plate. There is no well-defined typical wastage level - figures as low as 5% (Forbes-Ewan and Morrissey, 1989) and as high as 35% (French, 1975) have been reported. In this study, all forms of wastage combined to give a wastage rate of about 24%. If an intake of 13 500 kJ is to be achieved with a wastage rate of 24%, about 18 000 kJ needs to be provided to the kitchen each day for each person on victualling strength. However, 24% wastage is higher than we have found previously for Navy. At HMAS Cerberus, wastage of edible food accounted for 12% of total food available. Thus wastage at HMAS Albatross was twice as great as it was at HMAS Cerberus. This rate could be reduced by reducing the amount of food prepared in bulk beforehand and increasing the number of 'short order' meals available. If wastage can be reduced to 10-15%, the daily food entitlement could be reduced to 15 000 - 16 000 kJ.

Thirdly, the study cohort derived only 71% of their food intake from the Main Galley. This was despite agreeing to eat as often as possible at the Galley during the study (to allow maximum accuracy in the measurement of food intake). Meal attendance by other sailors was barely 50%, i.e. it appears that about half the food eaten by sailors at HMAS Albatross is coming from outside sources. This has implications for both peace-time and war-time feeding. During peace-time, it is not necessary to provide the entire 15 000 - 16 000 kJ, because sailors are obtaining much of their food requirement from outside the galley. However, during war, access to commercial food sources may be restricted, and meal attendance may be much greater than the observed 50% at HMAS Albatross. If so, the DVA may have to be revised in the event of mobilisation.

With respect to composition of the diet, sailors eating at HMAS Albatross appear to be eating similarly to the civilian Australian population. The contributions of protein, fat and carbohydrate to total energy intake were very similar to the average figures reported by the Department of Community Services and Health (1987b) for young Australians. However, the Better Health Commission (1986) regards the current level of fat intake as excessive. Fat now provides 35% or more of energy intake both in Australia generally and at HMAS Albatross. The Better Health Commission recommends that fat consumption should be reduced to provide no more than 33% of energy.

There are three main ways in which the problem of excessive fat consumption can be approached. Firstly, the food in the mess can be prepared with less fat. This may be achieved by, for example, grilling meat. The current (at least in June 1988) method of 'grilling' meat is really shallow fat frying. This would require the installation of a flame grill. A second, related approach, is to present foods in such a way that diners have a choice between high- and low-fat foods. As examples, potato could be served with a container of sour cream beside the bain-marie; beans could be presented with a jug of melted butter; if fried rice is served, a bain of boiled rice could also be made available. It is then up to the diner to choose whether or not the high-fat accompaniment is taken. Currently, potato is often served with sour cream, the beans are often buttered and boiled rice is apparently not served as an alternative to fried rice. Similarly, low-fat milk and other dairy products could be made available alongside the whole milk and full fat products. Non-fat yogurt, cottage and ricotta cheese and low-fat ice confections are also readily available commercially. Salads could be presented with a minimum of dressing or mayonnaise, with bowls of dressing and mayonnaise beside them.

This is the approach taken by the US Army (Dee, 1986). Most milk now consumed in US Army messes is reduced-fat (about 2% fat, compared to the usual 3.8%). Troop

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acceptance of reduced-fat milk has been reported to be 'outstanding'. Fat intake is also being reduced by 'limiting the number of servings of fried foods, gravies, sauces, toppings and frostings'.

If fat intake is reduced, there should be a concomitant increase in the intake of 'complex carbohydrate' foods. These are bread and other cereals, fruits and vegetables. Ideally, the bread provided should allow a choice between wholemeal and white; most of the fruit and vegetables should be 'fresh' (i.e. not frozen, canned or dehydrated). Complex carbohydrate is the most suitable source of energy and nutrients for active people, and physical activity is encouraged in all three Services to promote physical fitness.

However, provision of low-fat alternatives is not, of itself, enough. Australians are accustomed to high-fat diets and most sailors would be likely to ignore the low-fat alternative foods unless they have the knowledge necessary to make an informed choice. Education in sound nutrition is needed before such foods as reduced-fat milk and boiled rice are likely to have adequate acceptability. Because of the importance of nutrition to military fitness and long term health, it is suggested that lectures on nutrition be included as an integral component of the recruit course. It is understood that catering students at HMAS Cerberus already receive lectures from a nutritionist. Perhaps greater use of the nutritionist could be made along the lines suggested above. These lectures could provide the basis of a 'nutritional awareness program' for Navy similar to Army's and RAAF's programs.

The British Army may have an even greater problem with high fat intakes - almost 44% of energy may be derived from fat in British Army messes. At a recent conference, Major J. Edwards of the (British) Army Catering Corps pointed out that education and provision of lower-fat alternative foods are essential if healthier eating practices are to be adopted (Edwards, 1987). His final sentence sums up the above arguments: 'By taking careful note of food preferences, making people aware, creating the stimulus and providing them with the opportunity to make an informed choice, then the final decision is in their hands'.

Based on the results reported in the tables of food composition, average mineral and vitamin consumption at HMAS Albatross was in excess of the RDI for the range of micronutrients assessed. However, direct analysis of some samples suggests that heat-labile vitamins may not be present in the quantities reported in the food tables. The degradation of heat-labile vitamins which occurred in foods left on the servery for up to two hours is worthy of further study. MRL Tasmania is conducting laboratory experiments involving simulation of this practice under controlled conditions. Pending the outcome of these experiments, it is suggested that foods which are to be kept warm should be prepared as close as possible to the time of commencement of the meal. This applies especially to foods containing cooked vegetables.

Intake of sodium (averaging 190 mmol) was higher than the national average of 160 mmol (Better Health Commission, 1986) and well above the recommended maximum daily intake of 100 mmol (NH & MRC, 1988). It was observed that little or no salt was added during cooking in the Main Galley, however, much use was made of 'flavour boosters'. These consist mostly of salt and this is probably the major source of the high salt intake. It is suggested that high-salt boosters be used sparingly. If this reduction is carried out gradually, i.e. over a period of several months or even a year, acceptability is unlikely to be adversely affected, because the taste for salt is largely dependent on habitual intake levels. Providing reduced-salt forms of foods such as bread, butter, margarine, peanut butter and cheese will also help to reduce salt intake towards the recommended level.

Although the mean intake/balance results for EE agreed quite closely with the mean result for EE by doubly-labelled water, there was poorer concordance between the two methods for individuals. This occurred equally in both the active and inactive groups. Using the doubly-labelled water results as the reference, the intake/balance method underestimated EE in six subjects and led to an overestimate in five. The mean level of underestimation was 2 625 kJ, while mean overestimation was 1 930 kJ. Thus the underestimates and overestimates virtually cancelled each other, explaining how the mean results could be similar, despite relatively poor agreement between the two methods for individuals.

The results for food intake agreed more closely with EE by doubly-labelled water technique than did the results for EE by intake/balance method. For individuals, the mean difference between the results by these two methods (regardless of direction of the difference) was 1 740 kJ. This suggests the possibility that the 'balance' side of the intake/balance equation may have been a major source of error. This is quite likely over such a short study period (7 days). We have previously reported a similar discrepancy between EE by doubly-labelled water technique and EE by the intake/balance method (Forbes-Ewan et al, 1988).

The doubly-labelled water method did not provide consistent results for EE over the entire study period (about 16 days). This was expected for the active group, because 16 days was longer than the recommended period of 0.5 - 3.0 biological half-lives of the isotopes (Schoeller, 1988). However, it was not expected to occur in the inactive group, because their sedentary lifestyles led to longer biological half-lives of the isotopes. Nevertheless, for two inactive subjects, the EE results for the last 9 days do not closely resemble those of the first 7 days.

This is most likely due to analytical error, or sample contamination, rather than to any inherent flaw in the trial protocol. The evidence for this is that the results for the other four members of the inactive group are consistent over the 16 day study period.

It is concluded that a metabolic period of 7 days is adequate for accurate estimation of EE by doubly-labelled water for active and relatively inactive subjects.

Finally, it should be pointed out that the doubly-labelled water method of estimating EE has again been shown to be very useful under field conditions. It gave very similar mean results for EE to those obtained by the intake/balance method. It clearly differentiated between the mean EE of the active and inactive groups, and it is by far the simplest method for field use. However, although mean results obtained by the two techniques agreed quite well, there was poor concordance between the techniques for individual results. It is concluded that the doubly-labelled water technique can give similar estimates of mean, but not necessarily individual EE, to those obtained by the intake/balance method.

5. Conclusions

(i)   Food intakes and energy outputs vary enormously at HMAS Albatross, with some very active men likely to have twice the food requirements of sedentary women. However, average energy expenditure is probably quite close to the recommended food intake for

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moderately active young men. Based on the results of this study, food availability at the General Mess is more than adequate to meet food requirements, given the current attendance.

(ii)   Food wastage may be excessive. Combined kitchen/servery wastage was twice as great as at HMAS Cerberus. Steps may be needed to reduce this wastage. Perhaps the most important change needed is a decrease in the amount of pre-prepared food, and an increase in the number of short-order meals available.

(iii)   The low rate of meal attendance (< 50% of victualling strength), and luke-warm response to an acceptability survey, suggest that the acceptability of meals served at HMAS Albatross could be improved. Changes in catering practice, such as those suggested in Conclusion (ii) above, may assist with improving acceptability as well as nutrition. Giving diners greater choice - e.g. allowing them to put fatty gravies and sauces on their vegetables only if they want to - would also help. Ensuring fruit is fresh will also improve the diners' perception of the standard of catering in the General Mess. Education in healthy eating is also necessary before sailors are likely to make healthy food choices.

(iv)   Nutritional analysis of the diet of sailors eating at the General Mess indicates that the food is generally adequate in protein, vitamins and minerals. However, some doubt exists about the status of vitamin C and thiamine of sailors who rely on the General Mess for most of their nutrient intake. Improved catering practices described in Conclusion (ii) would reduce, or eliminate this potential problem.

(v)   The doubly-labelled water method appears to be accurate over study periods of about seven days, and it is the most suitable method for field studies of human energy expenditure.

6. Acknowledgements

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Table 1   Physical Characteristics of the Cohort

Subject No. (yrs)	Age	Height (m)	Weight (kg)		% Body Fat		Fat Mass (kg)		BMI
			Day 1	Day 8	Day 1	Day 8	Day 1	Day 8	Day 1
1	24	1.54	61.6	62.3	33.1	33.5	20.4	20.9	26.0
2	17	1.75	62.7	62.8	12.3	12.3	7.7	7.7	20.5
3	26	1.88	84.5	85.5	16.3	16.2	13.9	14.0	23.9
4	21	1.79	80.1	81.0	21.6	21.1	17.3	17.1	25.2
5	20	1.76	89.1	88.6	27.0	27.9	24.0	24.7	28.8
6	24	1.82	64.8	64.9	11.7	11.7	7.6	7.6	19.6
7	24	1.76	71.2	72.3	10.1	10.3	7.2	7.5	23.0
8	26	1.82	66.9	67.6	10.3	10.3	6.9	7.0	20.2
9	27	1.78	86.9	86.3	16.0	16.2	13.9	14.0	27.4
10	26	1.72	70.9	70.2	9.1	8.5	6.4	6.0	24.0
11	27	1.74	74.1	74.1	9.9	9.6	7.3	7.1	24.5
Mean*	23.8	1.78	75.1	75.3	14.4	14.4	11.2	11.2	23.7
SD	3.4	0.10	9.5	9.4	5.9	6.1	5.9	6.1	2.9
Australian**	20-24	1.80	77.1		17.4		13.4		23.7

* Male subjects, numbers 2-11
** Physical characteristics of adult Australian males (Fisher & Read, 1982)

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Table 2   Individual and Mean Daily Intakes of Energy, Protein, Fat, Carbohydrate (CHO) and Alcohol from the Main Galley (G), from Outside Sources (O) and in Total

Subject Number		Energy (kJ)	Protein (g)	Fat (g)	CHO (g)	Alcohol (g)
1	G	5 700	59	54	164	-
	O	3 570	33	48	76	-
	TOTAL	9 270	92	109	240	-
2	G	7 810	71	60	269	-
	O	6 075	42	71	171	-
	TOTAL	13 885	113	131	440	-
3	G	9 505	86	78	317	-
	O	3 980	20	18	151	19
	TOTAL	13 485	106	96	468	19
4	G	11 750	152	123	283	-
	O	1 860	6	12	44	21
	TOTAL	13 610	158	135	327	21
5	G	5 540	84	65	103	-
	O	4 655	20	37	184	-
	TOTAL	10 195	104	102	287	-
6	G	9 380	99	96	255	-
	O	-	-	-	-	-
	TOTAL	9 380	99	96	255	-
7	G	11 930	117	102	365	-
	O	8 100	62	63	273	13
	TOTAL	20 115	179	165	638	13
8	G	12 045	131	139	287	-
	O	2 190	16	22	59	6
	TOTAL	14 235	147	161	346	6
9	G	6 890	91	79	149	-
	O	5 610	37	43	148	32
	TOTAL	12 510	128	122	297	32
10	G	14 185	106	105	528	-
	O	3 100	24	18	128	-
	TOTAL	17 285	130	123	656	-
11	G	9 965	118	95	273	-
	O	4 300	23	40	152	-
	TOTAL	14 265	141	135	425	-
Mean Total*		13 895	119	126	414	9
± SD		3 103	44	24	141	12
RDI**		13 200	55	-	-	-

*   Male (subjects 2-11)
**   For moderately active young men (NH & MRC, 1988)

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Table 3   **Individual and Mean Daily Intakes of Minerals from the Main Galley (G) from Outside Sources (O) and in Total**

Subject No.		Mean Intake (mg/day)				
		Sodium	Potassium	Calcium	Phosphorus	Iron
1	G	1 645	2 420	650	905	9
	O	770	1 610	875	800	4
	TOTAL	2 415	4 030	1 525	1 705	13
2	G	2 555	2 330	915	1 160	14
	O	1 415	1 590	390	600	8
	TOTAL	3 970	3 920	1 305	1 760	22
3	G	3 455	3 245	650	1 185	16
	O	615	205	145	310	4
	TOTAL	4 070	4 450	795	1 495	20
4	G	4 875	3 910	1 145	1 875	18
	O	370	515	115	120	1
	TOTAL	5 245	4 425	1 260	1 995	19
5	G	1 770	2 020	170	895	10
	O	1 490	1 050	155	435	5
	TOTAL	3 260	3 070	325	1 330	15
6	G	3 475	3 315	1 260	1 500	14
	O	-	-	-	-	-
	TOTAL	3 475	3 315	1 260	1 500	14
7	G	3 880	4 445	930	1 860	22
	O	2 250	2 765	500	1 105	16
	TOTAL	6 130	7 210	1 430	2 965	38
8	G	5 435	4 935	760	1 590	19
	O	415	510	305	325	1
	TOTAL	5 850	5 445	1 065	1 915	20
9	G	2 675	2 850	390	1 020	14
	O	1 130	1 030	230	525	4
	TOTAL	3 805	3 880	620	1 545	18
10	G	5 250	5 355	1 135	1 990	23
	O	315	1 555	145	375	6
	TOTAL	5 565	6 920	1 280	2 365	29
11	G	4 180	2 895	880	1 485	19
	O	970	1 360	220	575	11
	TOTAL	5 150	4 255	1 100	2 060	30
Mean Total*		4 650	4 685	1 045	1 895	23
± SD		1 050	1 410	355	495	8
RDI**		900-2 300	1 950-5 460	800	1 000	5-7

*   Male (subjects 2-11)
** For young, moderately active men (NH & MRC, 1988)

Table 4 Individual and Mean Daily Intakes of Vitamins from the Main Galley (G), from Outside Sources (O) and in Total

Subject No.		Retinol (μg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)
1	G	520	1.4	2.2	18	65
	O	420	0.4	2.0	11	9
	TOTAL	940	1.8	4.2	29	74
2	G	385	1.9	3.1	18	167
	O	135	0.9	0.8	10	40
	TOTAL	520	2.8	3.9	28	207
3	G	590	2.3	3.0	28	138
	O	35	0.3	0.5	6	50
	TOTAL	625	2.6	3.5	34	188
4	G	740	2.0	3.6	28	124
	O	35	0.1	0.2	2	67
	TOTAL	775	2.1	3.8	30	191
5	G	235	1.1	1.4	18	31
	O	10	0.4	0.4	6	8
	TOTAL	245	1.5	1.8	24	39
6	G	870	1.8	3.4	18	117
	O	-	-	-	-	-
	TOTAL	870	1.8	3.4	18	117
7	G	930	2.5	3.9	32	160
	O	210	1.2	3.0	26	89
	TOTAL	1 140	3.7	6.9	58	249
8	G	630	2.3	3.0	32	125
	O	160	0.2	0.4	3	12
	TOTAL	790	2.5	3.4	35	137
9	G	510	1.2	2.0	20	89
	O	100	0.4	0.5	8	14
	TOTAL	610	1.6	2.5	28	103
10	G	620	2.9	3.7	31	171
	O	130	0.4	0.6	6	68
	TOTAL	750	3.3	4.3	37	239
11	G	510	2.3	3.5	35	120
	O	190	0.9	1.4	34	58
	TOTAL	700	3.2	4.9	69	178
Mean Total*		703	2.5	3.8	36	165
± SD		235	0.7	1.4	16	65
RDI**		750	1.3	2.0	21	40

* Males (subjects 2-11)
** For young, moderately active men (NH & MRC, 1988)

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Table 5   **Results of Isotopic Analysis of Urine Samples ('/oo Deviation from Vienna SMOW)**

Subject Number	Oxygen-18				Deuterium			
	Day 0	Day 1	Day 8	End*	Day 0	Day 1	Day 8	End*
1	-0.90	209.90	82.63	30.13	11.6	1021.9	490.8	226.3
2	-2.12	154.65	84.53	31.55	7.6	731.5	488.3	248.0
3	-1.59	121.28	69.49	27.35	6.7	638.1	426.1	224.7
4	-2.28	132.24	71.44	26.88	-3.3	661.2	416.3	208.2
5	-2.61	131.79	75.3	30.89	11.1	635.0	431.0	232.0
6	-2.47	163.07	69.75	18.55	-1.5	811.9	424.4	157.1
7	-2.33	140.36	51.88	10.13	-5.6	706.4	333.0	113.1
8	-2.49	132.24	65.32	21.71	-6.5	646.5	388.2	173.0
9	-2.12	128.83	56.09	18.04	-4.3	604.6	319.4	143.3
10	-2.18	139.13	53.03	12.53	8.7	715.0	344.3	129.0
11	-2.28	133.90	60.04	-	-1.9	670.5	369.1	-

* The end of the study was day 17 except for subject 8 (day 16), subjects 2, 7 and 10 (day 18) and subject 11 (unavailable).

Table 6   Total Body Water (TBW). Elimination Rate Constants for Deuterium (kH) and Oxygen-18 (k_o). CO_2 Production.   Respiratory Quotient (RQ) and Energy Expenditure (EE) for the Periods Day 1 - Day 8 (1), Day 8 - End of Study (2) and Day 1 - End of Study (3)

Subject No.	TBW (moles) 1*	TBW (moles) 2/3+	k_H 1	k_H 2	k_H 3	k_o 1	k_o 2	k_o 3	CO_2 (L/day) 1	CO_2 (L/day) 2	CO_2 (L/day) 3	RQ#	EE (kJ/day) 1	EE (kJ/day) 2	EE (kJ/day) 3
1	1 676	1 682	0.1066	0.0892	0.0968	0.1322	0.1100	0.1198	385	311	345	0.85	9 220	7 450	8 260
2	2 231	2 231	0.0585	0.0693	0.0648	0.0847	0.0947	0.0905	560	535	545	0.87	13 170	12 580	12 810
3	2 883	2 903	0.0584	0.0727	0.0665	0.0782	0.0998	0.0904	533	744	768	0.88	12 420	17 340	15 240
4	2 564	2 586	0.0657	0.0761	0.0716	0.0859	0.1031	0.0960	480	585	535	0.84	11 600	14 140	12 930
5	2 614	2 592	0.0566	0.0714	0.0649	0.0779	0.0938	0.0868	526	540	531	0.86	12 480	12 810	12 600
6	2 320	2 320	0.0924	0.1098	0.1022	0.1185	0.1371	0.1290	556	571	565	0.86	13 190	13 550	13 410
7	2 608	2 625	0.1062	0.1048	0.1054	0.1383	0.1470	0.1434	774	1 053	939	0.88	18 040	24 540	21 880
8	2 442	2 453	0.0719	0.0985	0.0861	0.0981	0.1288	0.1145	603	688	650	0.84	14 570	16 630	15 710
9	2 944	2 930	0.0903	0.0873	0.0886	0.1158	0.1178	0.1169	688	839	779	0.84	16 630	20 280	18 830
10	2 608	2 603	0.1063	0.1026	0.1041	0.1343	0.1323	0.1331	663	710	691	0.90	15 180	16 260	18 830
11	2 711	2 714	0.0850	-	-	0.1117	-	-	675	-	-	0.87	15 870	-	-
Mean	2 509	2 493	0.0816	0.0878	0.0851	0.1069	0.1164	0.1118	586	674	635	0.86	13 850	15 560	14 750
± SD	349	360	0.0202	0.0155	0.0169	0.0230	0.0190	0.0203	109	201	167	0.02	2 510	4 667	3 733

* TBW for period 1 is the mean of TBW values calculated from the skinfold results on Day 0 and Day 8 (TBW = 0.73 x FFM).
+ TBW for periods 2 and 3 is calculated from results of skinfold analyses conducted on Day 8.
# Calculated from food quotients.

Table 7   EE by Intake/Balance Method

Subject No.	1	2	3	4	5	6	7	8	9	10	11
EE (kJ/day)	6 710	13 885	13 485	14 780	6 515	9 380	18 555	14 235	12 500	19 735	15 325

Annex A

Customer Satisfaction Survey

1.   The Navy wants to know how effective its current system of feeding is.
HMAS Albatross has been chosen as a good example of a large shore establishment, where
sailors have a wide range of occupations.   A study is being conducted this week to determine
the food intake and energy expenditure of a group of sailors eating in this mess.   Similar
studies will be conducted on other shore establishments, on surface ships and on a submarine.

2.   As part of these studies, we also want to know whether or not sailors eating at Naval
messes are satisfied with the quantity, quality and variety of food provided.

3.   By filling out this questionnaire, you will be helping to identify any problems with
Naval feeding.   As a result, the Navy will be in a position to ensure that the acceptability of
meals served in Naval messes is as high as possible.

4.   You are asked to take one questionnaire with you, fill it in, and return it to one of
the civilian scientists when you next eat in this mess.   Remember, this is your chance to help
improve the quality of meals served throughout the Navy;   the accuracy of your answers will
affect the quality of your meals in the future.

5.   The questionnaire asks you to consider the meals served in this mess over the past
3 weeks, **not** just this week.   Try not to let your responses be determined by today's meals
alone.

6.   Please indicate how many years you have been in the Navy:

YEARS _____

GENERAL

1.   Are the meal timings in this dining room suitable to you?   (Circle your response).

2.   If you would prefer any changes to meal timings list them:

Midweek: _____   Weekend: _____

                        _____   _____

                        _____   _____

3.   As an overall assessment how would you rate the meals in this dining room over the **past three weeks**?   (Circle your response)

VERY POOR   POOR   AVERAGE   GOOD   VERY GOOD

4.   Do you always get enough food in this dining room? (Circle your response)

                                                                YES/NO

5.   Respond to the following items by circling the appropriate word/words.

Cleanliness of the servery:

VERY POOR   POOR   AVERAGE   GOOD   VERY GOOD

Cleanliness of the dining room:

VERY GOOD   GOOD   AVERAGE   POOR   VERY POOR

MAIN COURSES

6. What is your assessment of the main courses served in this dining room over the past three weeks?   (Circle your responses)

QUALITY:	VERY POOR	POOR	AVERAGE	GOOD	VERY GOOD
TASTE:	VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
APPEARANCE:	VERY POOR	POOR	AVERAGE	GOOD	VERY GOOD
QUANTITY:	VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
VARIETY:	VERY POOR	POOR	AVERAGE	GOOD	VERY GOOD

7. Are all meals served at suitable temperatures: YES/NO

8. Is there a reasonable selection of main meal items for most of the meal time?

                                                                    YES/NO

9. Are a good variety of vegetables always available?   NO/YES

10. Are salads always available as an alternative?   NO/YES

11. What changes, if any, would you like to see made to the main courses served in this dining room?

_____

_____

_____

DESSERTS

12. What is your opinion of the desserts served in this dining room over the past three weeks? (Circle your responses)

QUALITY:	VERY POOR	POOR	AVERAGE	GOOD	VERY GOOD
TASTE:	VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
APPEARANCE:	VERY POOR	POOR	AVERAGE	GOOD	VERY GOOD
QUANTITY:	VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
VARIETY:	VERY POOR	POOR	AVERAGE	GOOD	VERY GOOD

13. Are desserts served at correct temperatures?   NO/YES

14. Are the desserts always fresh?   YES/NO

15. What changes if any would you like to see made to the desserts served in this dining room?

_____

_____

_____

OTHER FOOD ITEMS

16. Is enough bread always available?   YES/NO

17. Is the bread always fresh?   NO/YES

18. Do you get a combination of sliced bread and rolls?   YES/NO

19. Is wholemeal bread available?   NO/YES

20. Is there enough milk for your needs?   YES/NO

21. Is there a complete range of condiments available to you?

        NO/YES

22. Is fruit available at each meal?   YES/NO

23. Is the fruit fresh?   NO/YES

24. Are the full range of hot drinks available?   YES/NO

25. Are cold drinks served during warm weather?   NO/YES

26. Can you always order early or late meals if your work situation demands it?

                                                                    YES/NO

27. Are these meals of a suitable quality?   NO/YES

28. If you responses "No" to any of questions 16 to 27 make any comments about them here:

_____

_____

_____

_____

_____

_____

CONCLUSION

29. Has the standard of meals changed this week: YES/NO

            If so are they: A. Better
                                   B. Worse
            (Circle A or B)

30. Do you have any further comments to make on the meals in this dining room over the past three weeks?

_____

_____

_____

_____

_____

_____

        Thank you for completing this questionnaire.

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Food intake and energy expenditure of sailors at a large naval base

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SUBJECT GROUPS	0057L

ABSTRACT

Estimates were made of the availability, wastage and intake of food, and of the energy expenditure of a cohort of eleven sailors over a seven day period at HMAS Albatross, a large Naval base. In addition, an attempt was made to estimate energy expenditure for an additional period of approximately nine days. Five members of the cohort were classified as the 'active group' and the remaining six were 'inactive'. Two methods were used to estimate energy expenditure - the doubly-labelled water technique and an 'intake/balance' study. The results below are expressed as kilojoules (kJ) per person per day.

Food availability averaged 20 000 kJ, based on the number of sailors who actually ate at the mess. Based on victualling strength, food availability was about 10 000 kJ. Wastage of food amounted to 24% of food availability.

Mean food intake was 13 400 kJ with a standard deviation (SD) of ± 3 925 kJ. Food intake varied from 9 190 kJ (sedentary female) to 20 030 kJ (male triathlete). Energy expenditure by doubly-labelled water averaged 13 850 ± 2 510 kJ; the result by the intake/balance method was 13 200 ± 4 265 kJ.

It is concluded that food availability is more than adequate to meet requirements at current attendance rates. Food wastage during the period of this study was high. Suggestions are given on reducing fat and salt intake, and improving the retention of heat-labile vitamins in cooked foods. Finally, it is concluded that seven days is an appropriate period to study the energy expenditure of active and inactive subjects using the doubly-labelled water technique.